

Illinois Department of Transportation

2300 South Dirksen Parkway / Springfield, Illinois / 62764

BDE PROCEDURE MEMORANDUM

NUMBER: 36-03

SUBJECT: Guardrail

DATE: October 14, 2003

The information relative to short radius guardrail in this memorandum should be considered as a new Section, 38-6.09 in the BDE Manual.

The information relative to Type B guardrail in this memorandum should be considered as an addition to Section 38-5.01(a)(2) in the BDE Manual.

Background

1. Short Radius Guardrail

A sideroad or entrance within the length of need of a guardrail installation poses a severe challenge to the design of a safe roadside. The most common approach to this situation has been to install a short radius guardrail around one or both of the roadway radius returns. However, a vehicle impacting the radius at a high angle and speed may penetrate the barrier, or vault over the barrier after the posts lean back, creating a ramping effect. When penetration or vaulting does not occur, the vehicle will likely be decelerated at an excessive rate.

Recognizing that it is often not practical to change the site conditions by relocating the roadway or entrance to allow for the proper length of need of guardrail, the 2002 edition of the AASHTO Roadside Design Guide (RDG) acknowledges that some compromise will be necessary. The RDG recommends that some effort be made to keep errant vehicles from going behind, through, or over the barrier. There are currently no radius guardrail systems accepted under the criteria of National Cooperative Highway Research Program Report 350 (NCHRP 350), the benchmark for roadside safety hardware.

2. Type B Guardrail

Guardrail posts generally require a minimum of 2' of earth embankment behind the posts to develop the necessary strength in order to function as designed. The material in this memorandum provides one alternative design that may be applied where the embankment hinge point occurs at the back of the posts.

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Applicability

The procedures included in this memorandum will be effective for projects on the State highway system beginning with the April 1, 2004 letting.

Procedures – Short Radius Guardrail

1. Preliminary Engineering

During Phase I of a project, as stated in Section 11-2.04(g) of the BDE Manual, the designer should evaluate and establish roadside barrier warrants. Virtually any decision taken may affect right of way needs, earthwork quantities, or other issues that must be recognized early in project development. Decisions to address safety work at a later phase of the project may severely restrict the designer's options. Design exceptions require approval and documentation in the preliminary engineering report.

2. Design Alternatives

A. Relocate or Close the Intersecting Roadway/Entrance

This decision is the preferred solution and should be considered during project scoping, or at least during Phase I preliminary engineering. This decision will involve consideration of project scope, cost, and impacts to adjacent properties and the environment. Obviously, this will not always be possible, but when it is, it will provide the most positive solution to the roadside safety issue. If it is undertaken, additional consideration should be given to flattening sideslopes, widening embankments, etc. to reduce the need for the barrier.

B. Terminate the Guardrail in Advance of the Intersecting Roadway

When relocating or closing the roadway/entrance is not feasible or practical and where the nominal length of need may fall within the intersecting roadway, or just beyond it, the designer may choose to truncate the standard guardrail with an approved terminal section or impact attenuator in advance of the roadway. The decision to address the need for guardrail in this manner should be where judgment or analysis indicates this is preferable (flat slopes, minimal drop off) to the additional hazard posed by a short radius guardrail installation.

Termination of guardrail short of the length of need is considered a design exception and must be documented in the Phase I preliminary engineering report.

C. Radius Guardrail

If relocating a roadway/entrance or terminating the guardrail short of its length of need cannot be accomplished, the designer may consider radius guardrail systems.

Any radius guardrail system will impose constraints on how close it can be installed to a bridge, what radius can be used, and how far it must run along the intersecting sideroad.

The RDG recognizes the use of curved guardrails that were crash tested to National Cooperative Highway Research Program Report 230 (NCHRP 230), the predecessor to NCHRP 350. NCHRP 230 represents a past standard, now outdated, especially with regard to pickup trucks, a common vehicle in the current fleet. Currently, there is one design of radius guardrail that meets the NCHRP 230 criteria. This design is shown in Attachment A to this memorandum.

The design noted above as accepted under the NCHRP 230 criteria employs weakened posts in the radius area. These weakened posts break away upon impact, allowing the rail to form a deep pocket to gradually decelerate and capture the impacting vehicle. However, as the testing was successful only at the NCHRP 230 level, and in some cases only at reduced speeds, it still represents a significant compromise in roadside safety.

By contrast, the use of standard strong post guardrail imposes additional compromises to safety. The strong posts do not break away, but rather are pushed back on impact. At some point, the vehicle can then ride up and over the posts, vaulting the rail. When the strong post system does capture a vehicle, the deceleration may be excessive.

When terminating the radius guardrail system, the guardrail on the intersecting roadway should be completed to any required length of need and terminated with an appropriate end treatment. On a very low speed roadway, such as a private driveway, this may be a Type 2 terminal. On most public roadways, or other roadways where higher speeds are possible, a Type 1 Special terminal should be used. These terminals are important to provide adequate anchoring of the radius system, and safety for the traffic on the intersecting roadway.

1. NCHRP 230 Design (Weakened Post Design)

The decision to use the NCHRP 230 design is considered as a design exception, and must be documented in the Phase I preliminary engineering report.

Adherence to the details with the NCHRP 230 design is important. Performance can be critically impacted by rates of curvature, use

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of breakaway Controlled Releasing Terminal (CRT) posts, adequate deflection zone behind the curved guardrail and the appropriate end anchorages.

To allow for proper system performance, the designer should be aware of several important constraints:

- a. Use of the attached detail is limited to the radii shown and to intersection angles of 85 to 95 degrees. No extrapolations to radii shorter than 8.5' or longer than 35' should be attempted. Any job-specific designs for intermediate radii and/or other intersection angles should incorporate all features of posts, attachment, etc., and should use only full length (12'-6") guardrail panels, shop bent to the design radius in 5' increments.
- b. Because of the required deflection distance, it requires a considerable clear area behind the radius and adjacent guardrail. This area is detailed on Attachment A with the x and y coordinates.
- c. The slope in front of the installation should not be steeper than 15H:1V. Before installing this detail where there is superelevation on the main roadway, the designer should perform special analysis to determine the potential for vaulting of a vehicle. Contact BDE for assistance.
- d. It is important to have the 2' earth embankment behind the CRT posts to provide adequate bearing strength if hit. It is desirable that the slopes behind the guardrail not be steeper than 2H:1V.
- e. When used in close proximity to a bridge, this design should not be used unless there is room to apply an approved transition to the bridge rail (Type 6, or Type 6A).
- f. From FHWA Technical Advisory 5040.32: "In crash testing, some heavy debris was observed flying about in the area behind the impact. Judgment must be used when installing these sections where people are likely to be present in the area behind the curved section."

The acceptable crash tests involving these designs were limited to 50 mile per hour impact speeds for the large car. The designs did not pass for a 60 mile per hour impact. However, the strong post system is also deficient at high speeds, and this design may be used over the strong post radius rail system where a short radius system is inevitable at these speeds.

Because the NCHRP 230 radius guardrail system still represents some compromise in roadside design, we should make an attempt to shadow it from impacts. This can be done by applying a tangent run of guardrail (minimum is two Type 1 Special terminals, back-to-back) on the approach side of the intersecting roadway.

2. Radius Guardrail Using the Strong Post Design

The decision to use the strong post design is considered a design exception, and must be documented in the Phase I preliminary engineering report.

The "Strong Post" design is simply the Department's current Standard Type A guardrail installed on the necessary radius. Type B should not be used in radius applications, as it increases the likelihood that posts will only deflect partially and launch a vehicle.

This design may be considered where none of the above alternatives apply, or where special studies, site history, etc. indicate it is appropriate.

Because the strong post radius guardrail system represents some compromise in roadside design, we should make an attempt to shadow it from impacts. This can be done by applying a tangent run of guardrail (minimum is two Type 1 Special terminals, back-to-back) on the approach side of the intersecting roadway. (Figure 7.16 in the 2002 Roadside Design Guide.)

D. Other Solutions

Other solutions may be possible on a case-by-case basis. For example, in some locations it may be feasible to locate an impact attenuator system in the radius area.

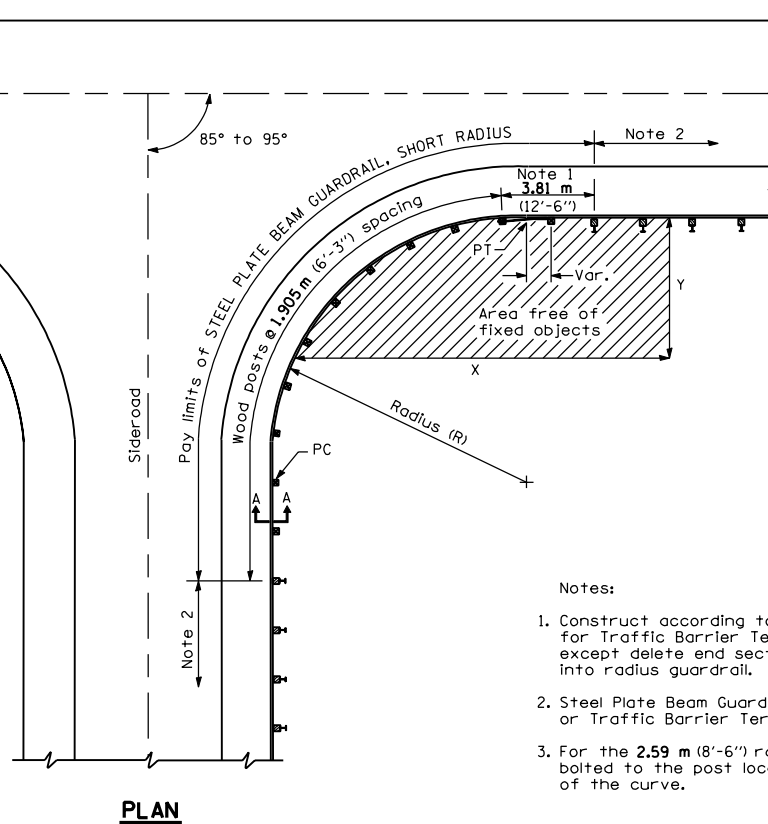
Procedures – Type B Guardrail Placed at Embankment Hinge Point

1. Design Information

Type B Guardrail may be installed when the distance from the back of guardrail posts to the embankment hinge point is from zero to two feet. The reduction in support from the embankment will increase the potential deflection of the system, and allowance for 3 feet (920 mm) deflection should be made when this design is used.

Engineer of Design and Environment Michael J. Hone

Attachments



- Notes:
1. Construct according to Standard 631011 for Traffic Barrier Terminal Type 2, except delete end section and splice into radius guardrail.
 2. Steel Plate Beam Guardrail Type A, Type B, or Traffic Barrier Terminal as specified.
 3. For the **2.59 m (8'-6")** radius, the rail is not bolted to the post located at the midpoint of the curve.

INSTALLATION CHARACTERISTICS PER DESIGN RADIUS (R)			
R	NO. OF WOOD POSTS	X	Y
2.59 (8'-6")	5 (Note 3)	7.6 m (25')	4.6 (15')
5.18 (17'-0")	6	9.1 m (30')	4.6 (15')
7.77 (25'-6")	8	12.2 m (40')	6.1 (20')
10.67 (35'-0")	11	15.2 m (50')	6.1 (20')

GENERAL NOTES

All slope ratios are expressed as units of vertical displacement to units of horizontal displacement (V:H).

All dimensions are in millimeters (Inches) unless otherwise shown.

DATE	REVISIONS	<p align="center">STEEL PLATE BEAM GUARDRAIL, SHORT RADIUS</p>
		BDE Memo 36-03 Attachment A